ENUMERATION OF FALL CHUM SALMON
BY SIDE-SCANNING SONAR IN THE
SHEENJEK RIVER IN 1984

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ABSTRACT

Fall chum salmon escapement in the Sheenjek River was monitored by hydroacoustic techniques for the fourth consecutive year in 1984. The sonar-estimated escapement was 25,120, being 45%, 13%, and 64% lower than estimates made in 1983, 1982, and 1981, respectively. Mean date of run passage was September 11.

Migrating salmon avoided the substrate during conditions of low water level and velocity and a large proportion passed upstream beyond the sonar counting range when such conditions prevailed. Chum salmon migrated along the west bank at the project site and migrated most actively during periods of darkness or suppressed light.

Beach seine samples were composed of 10% age 3_1; 81% age 4_1; and 9% age 5_1 chum salmon. Test gillnet samples resulted in 59% age 4_1 and 41% age 5_1 fish; underestimating the younger and overestimating the older age classes. Comparative mean size-at-age data are presented. Mean fecundity of 15 age 4_1 females was 2,446.

1.   Install a single side-scanning sonar unit and partial adult salmon weir to enumerate upstream migrants.

2.   Estimate percentage of upstream migrants passing the present sonar site undetected by sonar.

3.   Collect samples from the escapement with gillnets and beach seines to evaluate age-sex-size composition.

4.   Monitor selected climatological and hydrological parameters daily at the sonar site for use as baseline reference data.

METHODS

Salmon were enumerated with a single side-scanning sonar counter developed by the Hydrodynamics Division of Bendix Corporation. A 1977-model counter was used in 1984, as in 1983, whereas a 1981-model counter was used in 1982 and 1981. Site location was the same in all four years, with the sonar unit, an aluminum counting tower, and salmon weir being deployed from the west bank of the river approximately six rivermiles upstream of the river mouth (Figures 1 and 2).

Methods associated with installation of the sonar substrate, counting tower and salmon weir are described by Barton (1983a) as well as oscilloscope-sonar counter calibration procedures. Important differences between the 1977-and 1981-model sonar counters are described by Barton (1983b).

Although basic calibration procedures were the same in 1984, as in previous years, an additional ten minutes at the end of each 30-minute calibration period was spent examining offshore salmon distribution; i.e., salmon passing upstream beyond the 60-foot-long aluminum substrate. During each 10-minute period the sonar counting range was extended to 100 feet and the "data" switch turned off to prevent false counts from being registered by the metal target. An oscilloscope was then viewed and counts recorded separately for salmon passing over the substrate (inshore 60 feet) and those passing within 40 feet beyond the target. At the end of each 10-minute period the sonar counting range was dialed back to inside the target and the "data" switch turned back on. Counts made over the substrate (inshore 60 feet) in each 10-minute period were added to the sonar counter tape printout for the hour in which the calibration occurred.

Spatial distribution of salmon in the vicinity of the sonar site was also examined by use of a second sonar counter (1981 model). Procedures associated with use of the second counter will be discussed later in this report.

Daily drift-gillnetting was again conducted in 1984 to examine for salmon distribution as well as provide samples for age-sex-size (AWL) analysis. The location and duration of each drift, resulting catch and AWL data were recorded. In addition, a beach seine (100 feet long, 66 meshes deep, 2.5-inch stretch measure mesh) was periodically fished approximately six miles upstream of the sonar site to sample adult salmon for age-sex-size

restricted flow

sonar, weir,
and counting tower

camp area

log jams

very
shallow
water zone

log jam

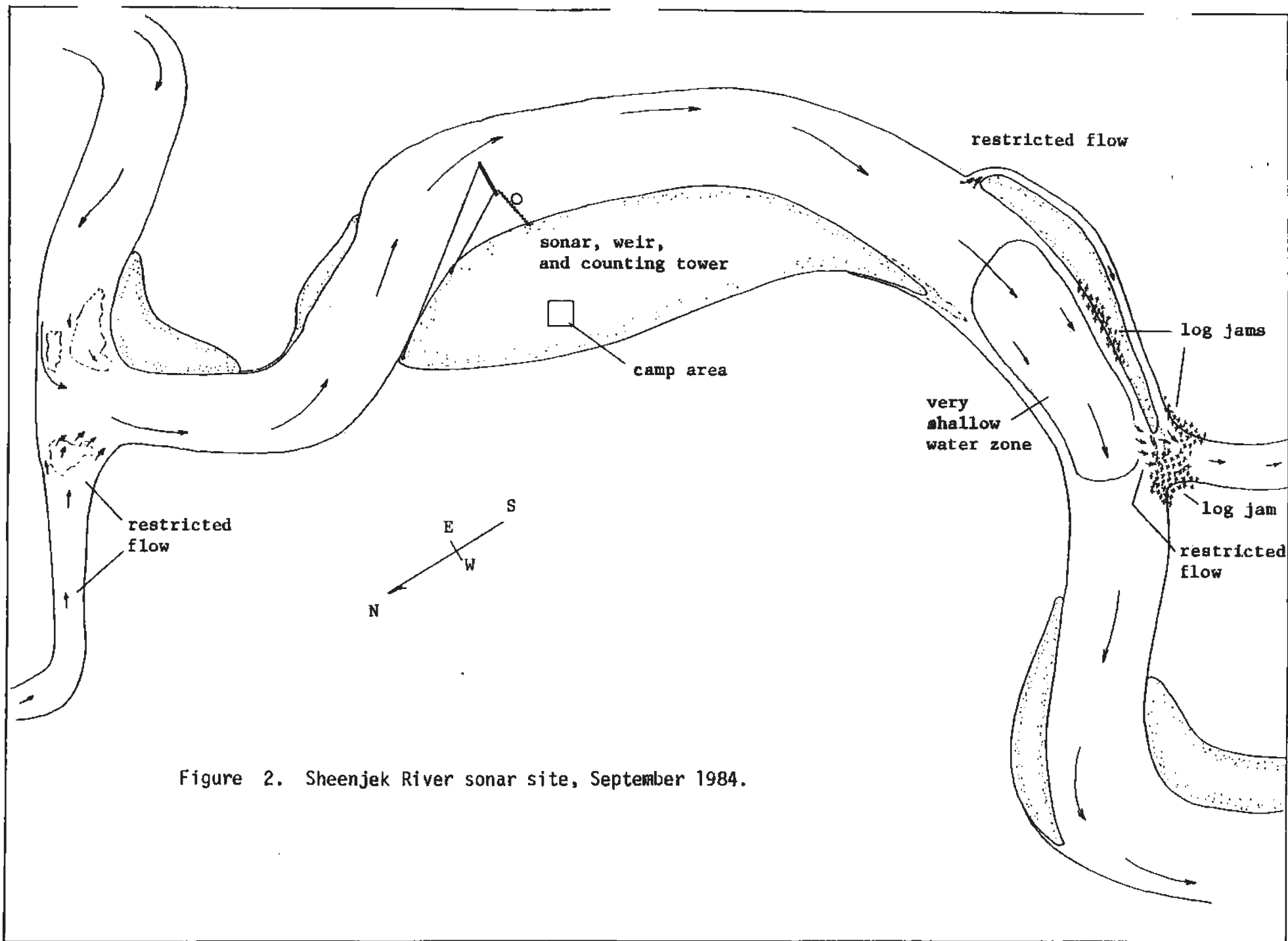restricted
flow

restricted
flow

S

E

W

N

Figure 2. Sheenjek River sonar site, September 1984.

Mundy (1982, 1984) developed a time-density model to describe salmon migration run timing. The pattern of the migration is described by the mean date of passage (a measure of the central tendency) and the standard deviation (a measure of dispersion). These statistics are calculated from the proportion of the total escapement occurring each day.

The mean date and standard deviation for the migration of fall chum salmon into the Sheenjek River based on sonar counts from roughly late August through late September are as follows: 1981-September 8, 5.12; 1982-September 12, 6.50; 1983-September 13, 7.26; and 1984-September 11, 7.67 (Figure 3). Run timing was somewhat similar based upon mean dates of passage ranging over a six-day period from September 8-13 during these four years, with the 1981 run the earliest.

Based upon the median date (i.e., date of 50% run passage), 1984 run timing was most similar to that of 1981, being earlier than in 1982 and 1983. The median dates were as follows: 1981-September 7; 1982-September 14; 1983-September 14; and 1984-September 9. These data suggest the 1981 and 1984 runs to have occurred about five-seven days earlier than in 1982 and 1983. Thus it is likely a higher proportion of the runs in 1981 and 1984 was unsampled in the two weeks prior to sonar operations than in 1982 and 1983.

The distinct diel pattern in salmon movement observed in previous years was again documented in 1984. Upstream migration commenced with the onset of darkness and continued through hours of suppressed light, decreasing with the onset of daybreak (Figure 4). Overall, the period of greatest movement occurred between 2100 hours and 0900 hours of the following morning (Figure 5). The peak of hourly passage was between 2200 and 2300 hours, when on the average 8.6% of a days count was made.

Abundance

The total 1984 sonar-estimated escapement from August 30 through September 25 was 25,120 chum salmon (Table 1). The sonar estimate was based upon daily oscilloscope calibrations. A total of 122 calibration periods averaging 32 minutes each, occurred over a 27-day period from August 30 through September 25. This represents 67 hours of calibration effort or approximately 11% of the total number of hours the sonar counter was functional. Most effort was placed on periods of the day when rate of upstream movement was highest:

0001 to 0300 hours	-	13% (9 hours)
0300 to 0900 hours	-	37% (25 hours)
0900 to 2100 hours	-	6% (4 hours)
2100 to 2400 hours	-	44% (29 hours)
		100% (67 hours)

The 1984 sonar estimate of fall chum salmon escapement is conservative, as in the previous three years, due to sampling only a portion of the run. It is also known that a small percentage of the salmon migrated past the sonar site undetected. However, when taken as an index of relative abundance, it can be said that the 1984 escapement was the lowest observed since sonar operations began in 1981. The 1984 estimate of 25,120 fall chum salmon
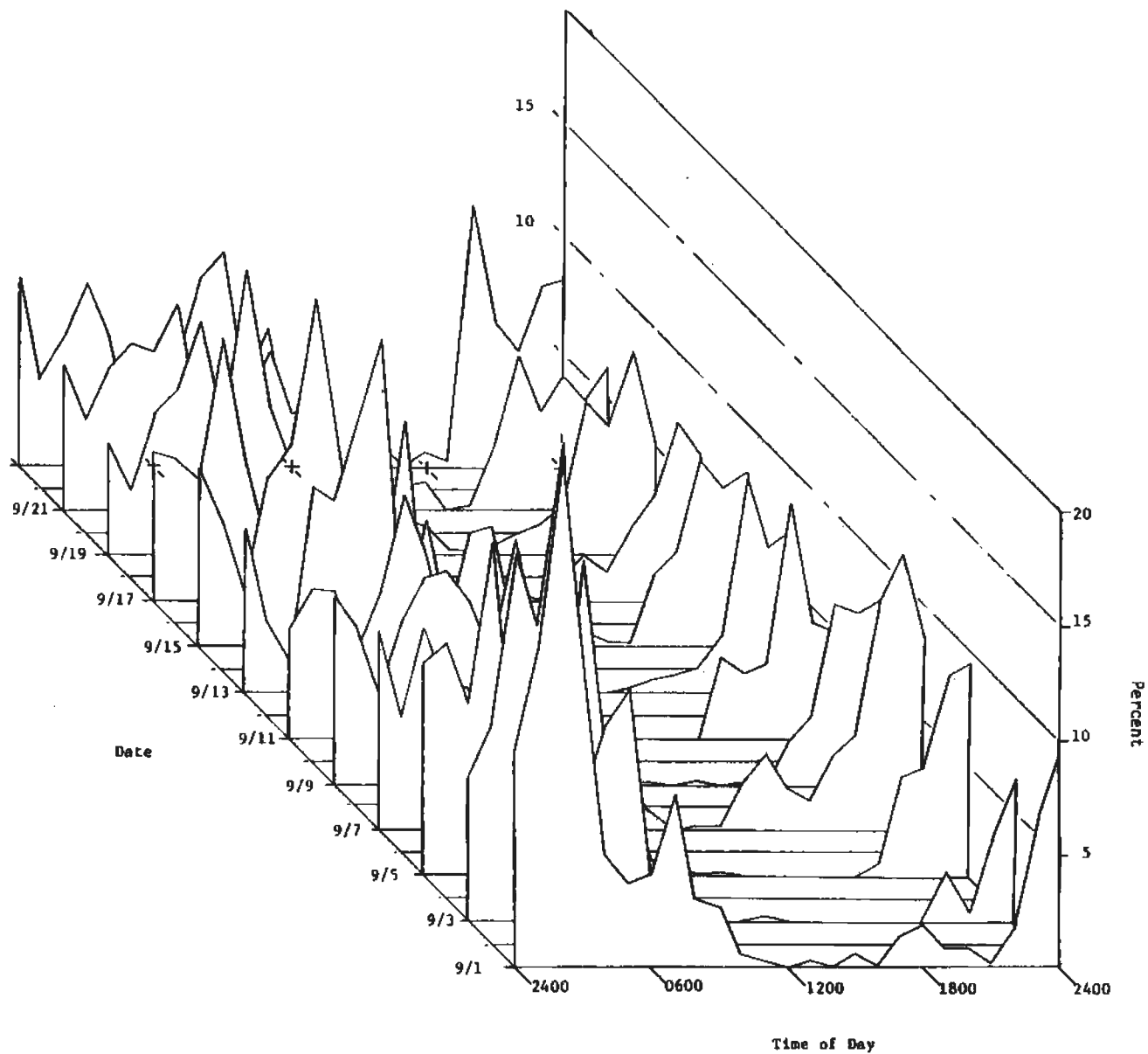
Figure 4. Temporal distribution of fall chum salmon by date in the Sheenjek River, September 1-23, 1984.

Table 1. Sheenjek River daily and cumulative sonar counts from August 30
through September 25, 1984.

| Date | Sonar Count | | | |
	Daily	Percent	Cumulative	Percent
8/30	257[a]	1.0	257	1.0
8/31	503	2.0	760	3.0
9/1	1,838	7.3	2,598	10.3
9/2	1,761	7.0	4,359	17.3
9/3	1,085	4.3	5,444	21.7
9/4	1,048	4.2	6,492	25.8
9/5	651	2.6	7,143	28.4
9/6	1,279	5.1	8,422	33.5
9/7	1,340	5.3	9,762	38.9
9/8	1,043	4.2	10,805	43.0
9/9	2,068	8.2	12,873	51.2
9/10	1,015	4.0	13,888	55.3
9/11	718	2.9	14,606	58.1
9/12	609	2.4	15,215	60.6
9/13	837	3.3	16,052	63.9
9/14	671	2.7	16,723	66.6
9/15	585	2.3	17,308	68.9
9/16	880	3.5	18,188	72.4
9/17	779	3.1	18,967	75.5
9/18	615	2.4	19,582	78.0
9/19	737	2.9	20,319	80.9
9/20	757	3.0	21,076	83.9
9/21	744	3.0	21,820	86.9
9/22	607	2.4	22,427	89.3
9/23	708	2.8	23,135	92.1
9/24	999	4.0	24,134	96.1
9/25	986[b]	3.9	25,120	100.0

[a] Actual count was 36 from 2201-2400 hours. Count was expanded to 257
based on percentage of salmon counted on 8/31, 9/1, and 9/2 from
0001-2200 hours.

[b] Actual count was 503 from 0001-1200 hours. Count was expanded to 986
based on percentage of salmon counted on 9/22, 9/23, and 9/24 from
1201-2400 hours.

Figure 6. Sheenjek River sonar site showing fall chum salmon catch per unit effort by river location from test gillnetting in September 1984.
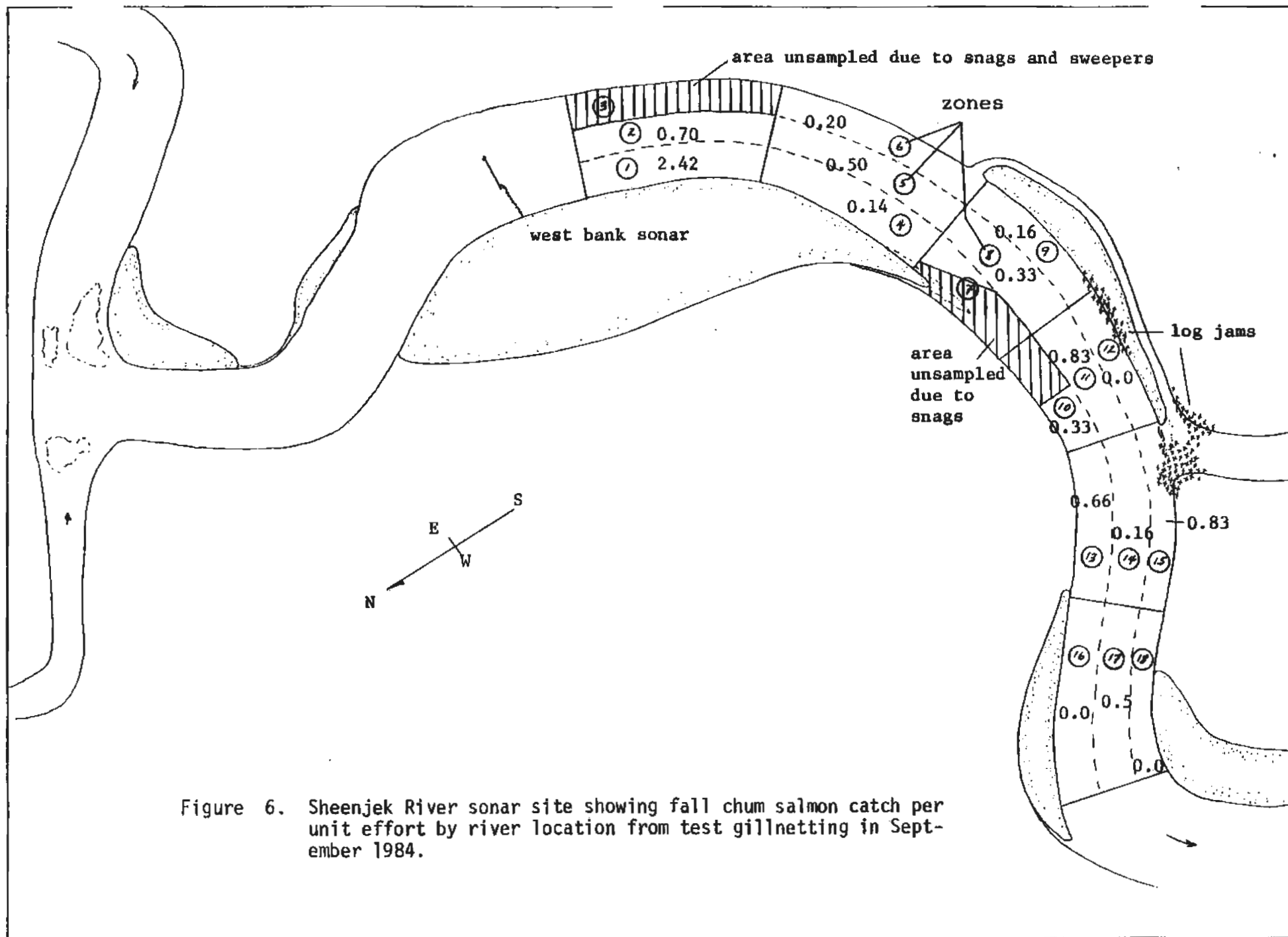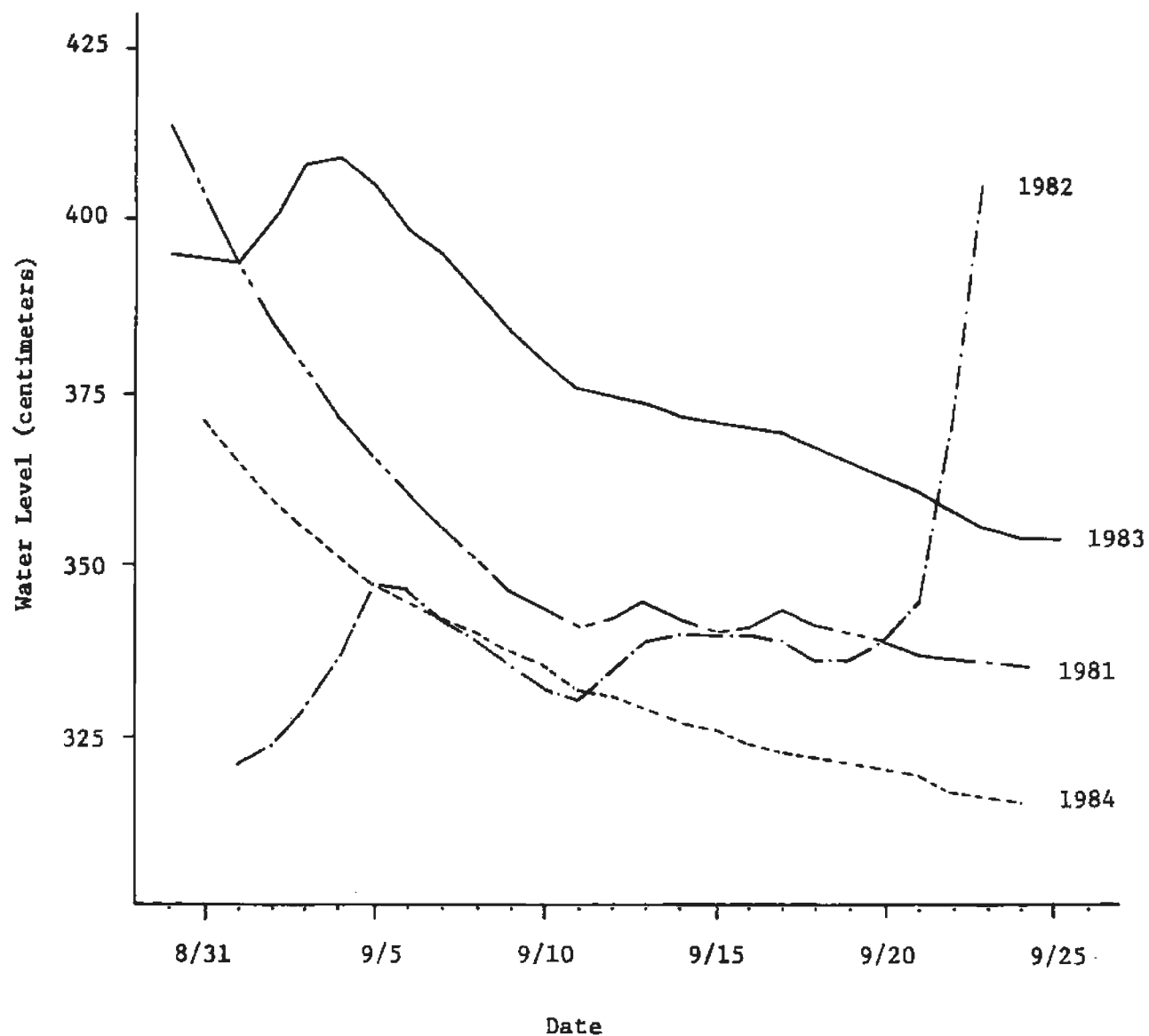
Figure 7. Estimated comparative water levels at the Sheenjek River sonar site based upon river depth profiles, 1981-1984. Only a partial depth profile was made in 1981.
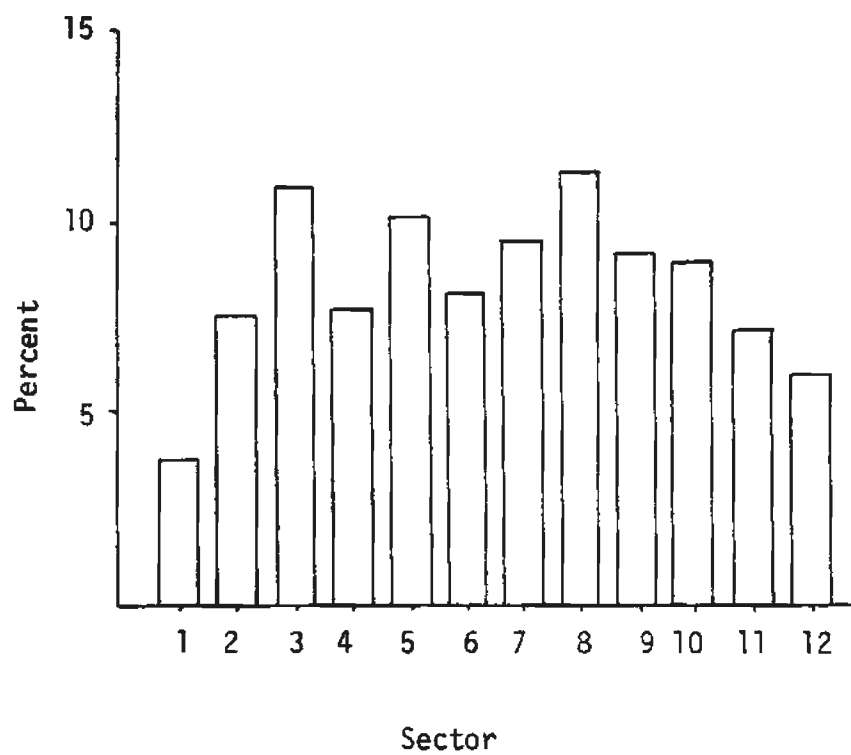
Figure 9. Average percentage of sonar counts by sector in the Sheenjek River from August 30 through September 25, 1984.

were ones which had possibly moved laterally along the downstream side of
the tube and skirted the substrate immediately around the target. This is
supported by a comparison of salmon counts by sonar sector on days the
substrate was moved and counts by sector on days subsequent to moving the
substrate. In all cases, the percentage of salmon counts in the outermost
sector (12) decreased the day subsequent to moving the substrate out
(Figure 8). Further, the average percentage of fish observed in the outer
40 feet beyond the target within 24 hours immediately preceding moving the
substrate was 13%; whereas, an average of only 3% was observed in that zone
within 24 hours immediately subsequent to moving the substrate (Table 3).
Thus, it appears that a substantial number of fish observed passing the
sonar site beyond the substrate target can be attributed to substrate
avoidance.

On the other hand, the 8% season estimate of offshore counts may be
considered somewhat conservative for two reasons. First, a portion of the
river on the east side was always uninsonified, even when the sonar range
was extended to 100 feet for calibrating. The greatest percentage of
offshore movement (15%) was observed to occur early in the season when this
uninsonified area was the greatest (Table 2). Second, there remained an
area beyond the target of uninsonified water beneath the extended (40
feet) sonar beam.

Nonetheless, data suggest a substantial portion of fish migrating upstream,
beyond the sonar range was from substrate avoidance.

4.   Experimental sonar counter results: To further examine spatial
distribution of upstream migrants a second sonar counter (1981-model) was
operated at various locations in the river. Only a counter and transducer
were used; no substrate was deployed. The counter was operated from three
different locations on September 12, 13, and 14 after obtaining
cross-sectional river profiles at each site. A comparison of river
profiles taken on September 1 and 12 at the project site (1977-model
counter) with those of the 1981-model experimental counting sites taken on
September 12 and 13 are shown in Figure 10.

It should be explained that both model counters are designed to properly
function at a counting range of 60 feet, even though the counting range
is variable and can be adjusted manually to a maximum of 100 feet
(Menin, personal communication, Bendix Corporation). Each counter
requires that a target (fish) receive a specific number of "valid hits"
before the counter will record it as a fish. This feature helps
eliminate debris problems. Although the 1977-model counter tabulates
counts into 12 sectors and the 1981-model counter into 16 sectors, valid
hit requirements for any given sector are a function of sonar model,
beam width, and distance from the transducer. Beam width at various
distances for both the 2° and 4° beam as well as valid hit requirements
by sector for each model counter are given in Appendix Table 3.

Regardless of the counting range selected, both the number of sectors as
well as valid hit requirements by sector remain unchanged and specific for
each model counter. However, sector length varies with counting range,
and is greatest at 100 feet. This is illustrated in Figure 11 for the
1981-model, 16-sector counter. At a counting range of 60 feet, each of

235'

45' 60' 75' 55'

Sonar site
September 1

28" 45"

144" 142"

216'

81' 60' 75'

Sonar site
September 12

28"

93"

129" 126"

189'

29' 60' 20' 20' 60'

Experimental Site 140'downstream
of sonar site - September 12

23"

80" 92" 123"

221'

62' 27' 28' 26' 36.5' 29' 12.5'

Experimental site 250 yds downstream
of sonar site - September 13
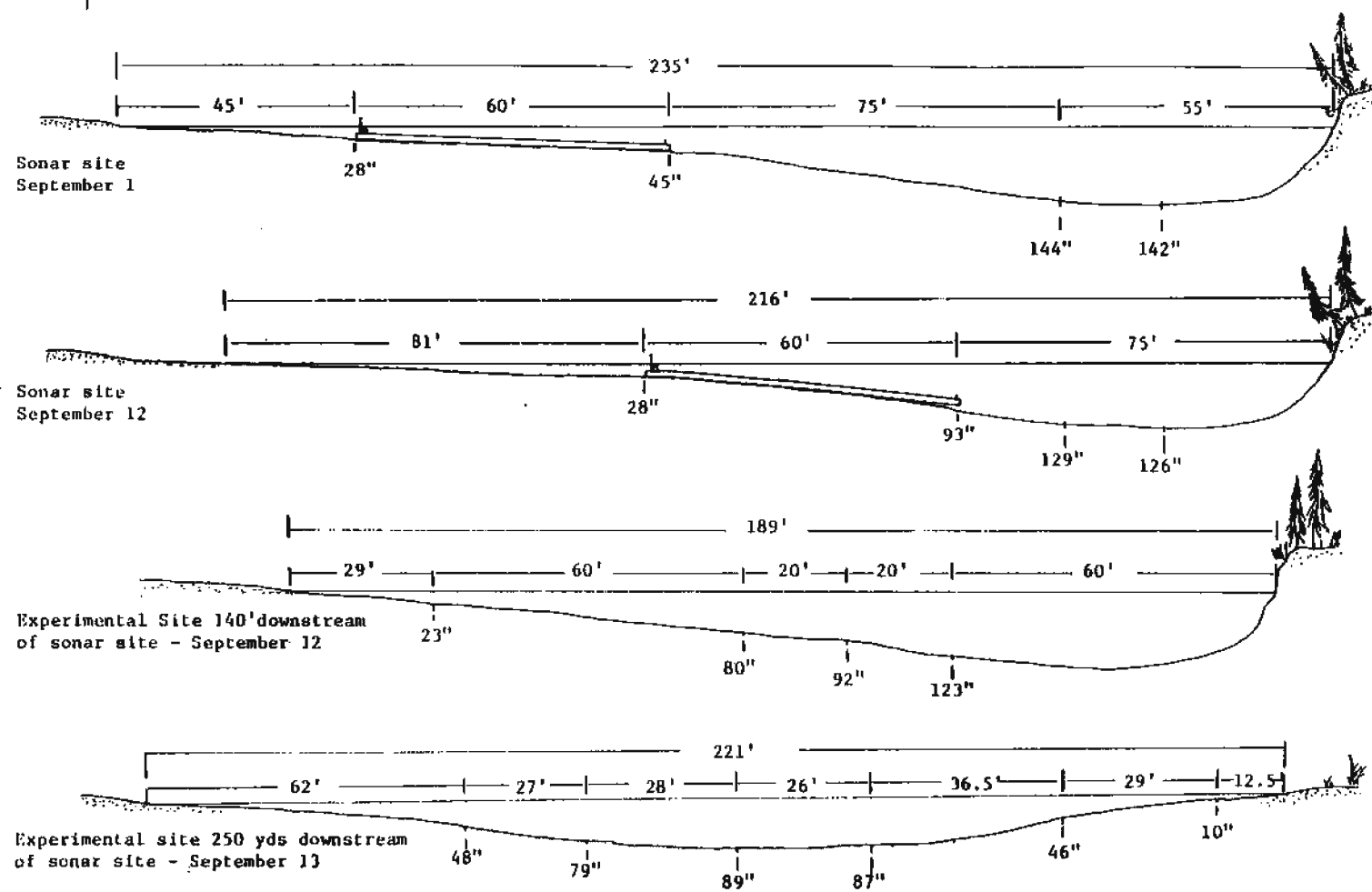
48" 79" 89" 87" 46" 10"

Figure 10. Comparative river depth profiles made on September 1 and 12 at the sonar site and profiles made on September 12 and 13 at two experimental sites, Sheenjek River 1984.

the 16 sectors represent 3.75 feet, whereas at 100 feet each of the 16 sectors represent 6.25 feet of lineal distance. Because the number of sectors and valid hit requirements per sector remain constant, and the beam width increases with distance, there is a tendency for the counter to overcount in the outer sectors of the 4° beam and in all sectors of the 2° beam when counting at 100 feet. For example: the 2° beam is approximately 2 feet wide at 60 feet and nearly 3.5 feet wide at 100 feet. In both instances seven valid hits are required (sector 16), but fish at 100 feet would be in the wider diameter 2° beam for a longer period than swimming through at 60 feet, thus, they would tend to generate more valid hits and be counted more than once (Menin, personal communication, Bendix Corporation). Sonar counts, when operating at extended range, can be accurately adjusted based on adequate oscilloscope calibrations. However, only the total count (all sectors combined) can be accurately adjusted. Counts by sector cannot be adjusted because the oscilloscope screen is too small for the observer to accurately evaluate salmon passage by sector.

The 1981-model counter was first operated from the west bank, 140 feet downstream of the 1977-model counter. The transducer was deployed 29 feet from shore and the counting range dialed to 100 feet. Since the dead range was set at 10 feet the actual amount of insonified water ranged between 39 and 139 feet from the west bank. The end of the 100-foot beam approximated the same distance from shore as the end of the 60-foot beam on the 1977-model counter located 140 feet further upstream.

The 1981-model counter was operated from 0001 to 0200 hours on September 12. During this period, both the 1977-and 1981-model counters were viewed with an oscilloscope to adjust for over or undercounting. The printer tapes printed out hourly counts (unadjusted) by sector for each sonar unit. The percent distribution of fish passing each sonar counter are shown by sonar sector in Figure 12. Very few salmon were observed passing in the outer two sectors of either sonar counter.

Whereas distribution of counts for the 1977-model counter which operated at the designed 60-foot range is correct, distribution of counts for the 1981-model counter is incorrect. Percent distribution of counts in the outer sectors of the 4° beam (4-8) and all sectors (9-16) of the 2° beam is probably high since these are the sectors which tend to overcount with the counting range extended beyond 60 feet. In other words, a disproportionate number of fish are shown in Figure 12 passing in the outer sectors for the 1981 counting unit. The actual percent distribution of counts in those outer sectors is likely of a lower magnitude.

The 1981-model counter was also operated for 10 hours from both the east and west banks from 0001 to 1000 hours on September 13 and 14, respectively, approximately 250 yards downstream of the 1977-model counter. Calibration time on the east bank amounted to only 3% of the total time the counter was operable and 18.5% on the west bank. Thus, calibrations were less than sufficient to accurately adjust counts for the total time each site was monitored, particularly since the counting ranges were expanded to 93 feet and 80 feet from the east and west banks, respectively.

River depth was very shallow and water velocities slower at the experimental site located 250 yards downstream of the project site. A comparison in surface water velocities taken on September 18 between the two sites is given below:

        1977 project site:
            -transducer (west bank)   1.2 ft/sec
            -target   2.2 ft/sec
            -midway between target and east bank   2.0 ft/sec

        experimental site: (250 yds downstream)
            -30 ft from west bank (transducer)   1.1 ft/sec
            -mid-river   1.6 ft/sec
            -13 ft from east bank (transducer)   0.9 ft/sec

It should be remembered that actual distribution by sonar sector was different than shown in Figure 13 due to overcounting tendencies in the outer sectors when operating beyond 60 feet. Percent distribution of counts past the experimental site, although incorrect, nonetheless reveal fish passing in the mid-river area. It is hypothesized that it is approximately in this vicinity of the river that fish began to orient toward the west bank, prior to reaching the project site (Figure 14).

Age-Sex-Size

Drift-gillnetting at the sonar site was only conducted through September 9, at which time low water levels precluded further sampling. During this period a total of 77 chum salmon were captured, 58% males and 42% females. Resulting age composition from 51 readable scales was 59% age 4_1 and 41% age 5_1 fish.

Beach seining was also attempted during early September at the sonar site. The seine was fished so as to form a trap and generally left open overnight and closed the following morning. Results from 12 sets revealed only male chums were captured; those which became entangled by their large teeth. Only 13 males had readable scales from a total catch of 34. All were age 4_1. Additionally, nine northern pike and four Arctic grayling were captured in the seine trap at the sonar site (Appendix Table 4).

A productive beach seining site was located on a gravel bar near Mahler's cabin approximately six rivermiles upstream of the sonar site. A total of 16 seine sets on seven different days between September 12 and 24 resulted in the following catch: 520 chum salmon, 168 Arctic grayling, and five round whitefish (Appendix Table 4). An additional 153 chum salmon taken in this period had been previously sampled (i.e., recaptures). A total of 297 chum salmon scales were ageable and age composition was: 10% age 3_1; 81% age 4_1; and 9% age 5_1. Sex composition was 63% males and 37% females.

The high number of recaptures can probably be explained by the presence of a major spawning area in close proximity to the seining location. Consequently, age and sex composition of these samples may not accurately reflect characteristics of the total chum salmon run. In view of the

Figure 14. Sheenjek River sonar site showing location of experimental sonar sites and hypothesized zone of fall chum salmon upstream migration.
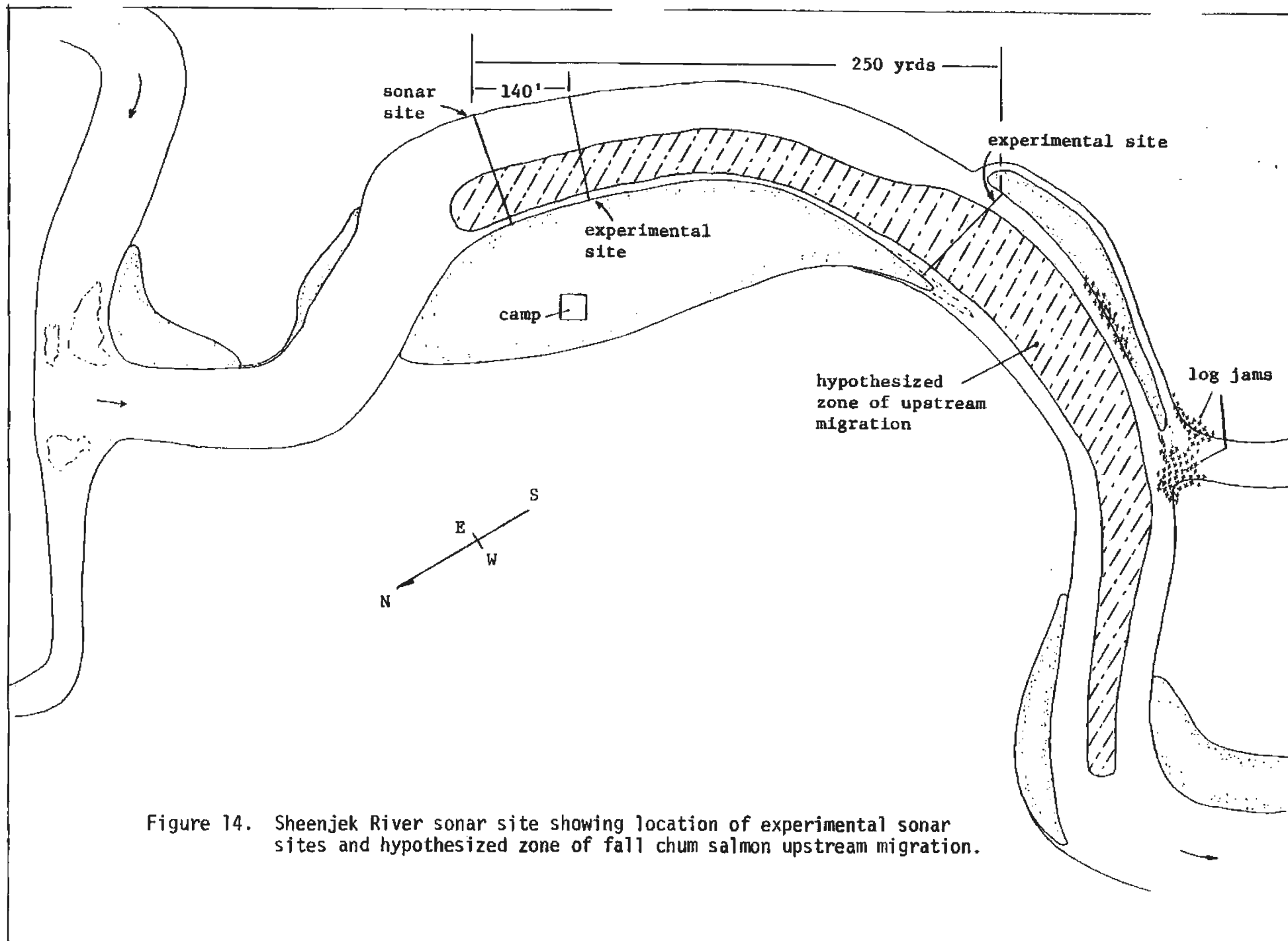
Table 4. Comparative age composition (in percent) of Sheenjek River fall chum salmon spawning escapements, 1974-1984[a].

Year	Age 3_1	Age 4_1	Age 5_1	Age 6_1	Sample size
1974	66	30	3	0	137
1975	3	95	2	1	197
1976	2	44	54	0	118
1977	11	73	16	0	178
1978	8	82	10	0	190
1979	-	-	-	-	-
1980	-	-	-	-	-
1981[b]	3	85	12	trace	340
1982[b]	3	47	50	trace	109
1983[b]	6.5	87	6.5	-	108
1984[b]	0	59	41	0	51
1984[c]	10	81	9	0	297

[a] All samples from carcasses on spawning grounds unless indicated otherwise.

[b] Escapement samples taken with 5-7/8-inch mesh gillnets at sonar site.

[c] Escapement samples taken with beach seine at rivermile 12 (Mahler's cabin).

bank before reaching the present counting location, due to physical and hydrological characteristics of the river.

5. Test gillnet sample results were biased toward larger, older-age fish as opposed to seine samples and, as such, their age-sex-size composition should not be considered typically characteristic of the chum salmon run. Beach seining or carcass sampling would seem to produce more unbiased results.

6. The 1984 sonar-estimated escapement followed the apparent trend in declining escapements to the Porcupine River in recent years, and were the lowest since sonar operations began on the Sheenjek River in 1981.

RECOMMENDATIONS

To more accurately document total fall chum salmon escapement to the Sheenjek River sonar enumeration should begin not later than mid-August, if funding is available, and continue as late as weather or water conditions permit (generally into the last week of September). Future attempts should be made with two sonar counting units, one deployed from each bank as close to the present site as possible, and without the use of aluminum substrates. The units should each be operated at a counting range of 60 feet and weired out as far as possible from each shore to ensure the least amount of uninsonified water exists in the mid-river zone.

Test gillnetting should be terminated and beach seining continued to examine age-sex-size characteristics of the fall chum salmon run. However, in view of the numerous and dispersed spawning areas in the Sheenjek River, perhaps the best measure of age-sex-size composition need be determined in the future by sampling chum salmon carcasses from selected spawning areas throughout the river.

Appendix Table 1. Surface water temperatures measured daily at the Sheenjek River sonar site, 1981-1984.

Date	Surface Water Temperature (C°)			
	1981	1982	1983	1984
8/29				
30	9		9	
31	8		9	6
9/1	7	8	8	6
2	6	7	7	6
3	7	7	6	6
4	5	7	5	6
5	5	7	5	6
6	5	7	5	6
7	5	7	6	5
8	5	7	6	6
9	5	7	7	6
10	6	6	7	6
11	6	7	8	6
12	6	7	8	7
13	6	7	7	6
14	6	6	7	6
15	6	7	7	6
16	6	7	7	6
17	6	7	6	6
18	5	7	5	6
19	5	6	5	6
20	4	6	4	6
21	4	5	4	5
22	3	Flood	5	5
23	3		3	5
24	3		2	5
25			0 (ice)	
26			0 (ice)	
Average	6	7	6	6

Appendix Table 3. Beam width at various distances for both 2° and 4° beams
and valid hit requirements by sector for 1977- and
1981-model Bendix side-scan sonar counters.

| Distance from transducer | Beam width[a](feet) | | Sector number | Valid hit requirement | |
	2° beam	4° beam		1977-model	1981-model
5	0.17	0.35	1	3	4
10	0.35	0.70	2	3	4
15	0.52	1.04	3	3	4
20	0.70	1.39	4	4	4
25	0.87	1.75	5	5	5
30	1.05	2.09	6	6	5
35	1.22	2.44	7	4	5
40	1.40	2.79	8	4	6
45	1.57	3.14	9	5	4
50	1.75	3.49	10	5	4
55	1.92	3.84	11	6	5
60	2.09	4.19	12	6	6
65	2.27	4.53	13		6
70	2.44	4.89	14		7
75	2.62	5.23	15		7
80	2.79	5.59	16		7
85	3.00	5.94			
90	3.14	6.28			
95	3.32	6.63			
100	3.49	6.98			

[a] Beam width or diameter in feet equals the tangent of one-half the beam size in degrees times twice the distance from the transducer.

Appendix Table 5. Comparative age, sex, and size composition of fall chum salmon sampled at various sites in the Porcupine River drainage, 1972, 1975, 1981-1984.[a]

		Age 3_1				Age 4_1				Age 5_1				Age 6_1				Total	
				length				length				length				length			
		n	(%)	$\bar{x}$	SD	n	(%)	$\bar{x}$	SD	n	(%)	$\bar{x}$	SD	n	(%)	$\bar{x}$	SD	n	(%)
1972 Fishing Branch River[b]																			
	male	1	(1.7)	610	-	20	(34.5)	620	31.8	1	(1.7)	649	-	-	-	-	-	22	(37.9)
	female	4	(6.9)	561	-	29	(50.0)	598	23.2	3	(5.2)	614	-	-	-	-	-	36	(62.1)
	total	5	(8.6)	571	29.3	49	(84.5)	607	29.0	4	(6.9)	623	-	-	-	-	-	58	(100.0)
1975 Sheenjek River[c]																			
	male	2	(1.0)	599	-	79	(40.1)	599	34.2	2	(1.0)	654	-	-	-	-	-	83	(42.1)
	female	5	(2.5)	544	23.0	108	(54.8)	582	27.8	1	(0.5)	520	-	-	-	-	-	114	(57.9)
	total	7	(3.5)	559	35.7	187	(4.9)	589	31.7	3	(1.5)	642	-	-	-	-	-	197	(100.0)
1981 Sheenjek River[d]																			
	male	2	(0.6)	547	-	139	(40.9)	620	27.5	32	(9.4)	637	42.4	1	(0.3)	620	-	174	(51.2)
	female	8	(2.3)	574	17.2	150	(44.1)	596	25.6	8	(2.3)	613	19.7	-	-	-	-	166	(48.8)
	total	10	(2.9)	569	25.9	289	(85.0)	608	29.1	40	(11.8)	632	40.4	1	(0.3)	620	-	340	(100.0)
1982 Sheenjek River[d]																			
	male	1	(1.0)	570	-	15	(14.0)	615	22.9	22	(20.0)	651	30.5	1	(1.0)	640	-	39	(35.8)
	female	2	(2.0)	525	-	36	(33.0)	601	22.9	32	(29.0)	621	22.0	-	-	-	-	70	(64.2)
	total	3	(3.0)	540	-	51	(47.0)	605	24.4	54	(49.0)	633	29.8	1	(1.0	640	-	109	(100.0)
1983 Sheenjek River[d]																			
	male	3	(3.0)	603	44.5	52	(48.0)	612	29.5	3	(3.0)	609	41.7	-	-	-	-	58	(54.0)
	female	4	(4.0)	554	23.8	42	(39.0)	592	22.3	4	(4.0)	625	25.7	-	-	-	-	50	(46.0)
	total	7	(7.0)	575	40.3	94	(87.0)	603	28.2	7	(7.0)	618	31.4	-	-	-	-	108	(100.0)

(Continued)

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Appendix Table 6. Age, length, and fecundity data taken from Sheenjek River fall chum salmon, September 1984.

Age	Length[a] (mm)	Fecundity
3_1	410	1,965
3_1	512	2,258
4_1	582	1,802
4_1	552	1,926
4_1	548	2,072
4_1	540	2,131
4_1	613	2,192
4_1	561	2,225
4_1	595	2,315
4_1	583	2,374
4_1	591	2,386
4_1	634	2,460
4_1	573	2,534
4_1	575	2,714
4_1	584	2,886
4_1	613	2,923
4_1	588	3,764
5_1	594	2,261
5_1	661	2,311
5_1	614	2,605
5_1	598	2,790
b	557	2,115
b	661	2,569
b	611	2,698
b	609	3,512

Age	Length			Fecundity		
	Range	Mean	SD	Range	Mean	SD
3_1	410-512	461	-	1,965-2,258	2,111	-
4_1	540-634	582	25	1,802-3,764	2,446	485
5_1	594-661	616	30	2,261-2,790	2,491	250
b	557-661	609	42	2,115-3,512	2,723	582

[a] Length measured from mid-eye to fork-of-tail.
[b] Age was undetermined.